

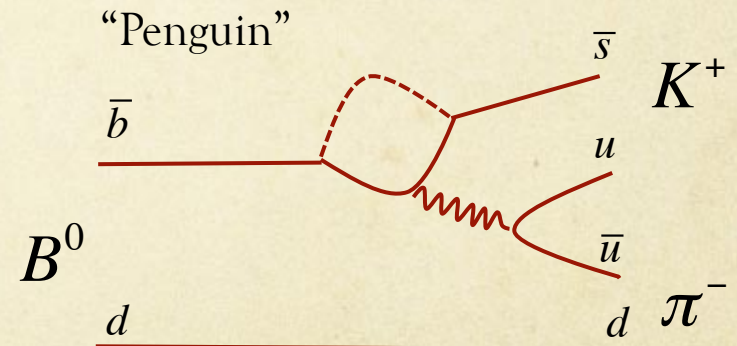
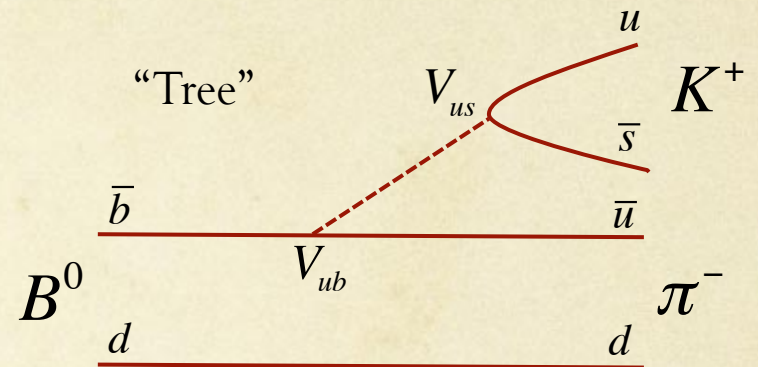
TeVatron DCPV Results

7th International Workshop on the CKM Unitarity Triangle
Cincinnati, September 28 - October 2, 2012

Michael J. Morello, for the CDF Collaboration
Scuola Normale Superiore of Pisa and INFN Pisa

Two-body non-leptonic Charmless B-decays

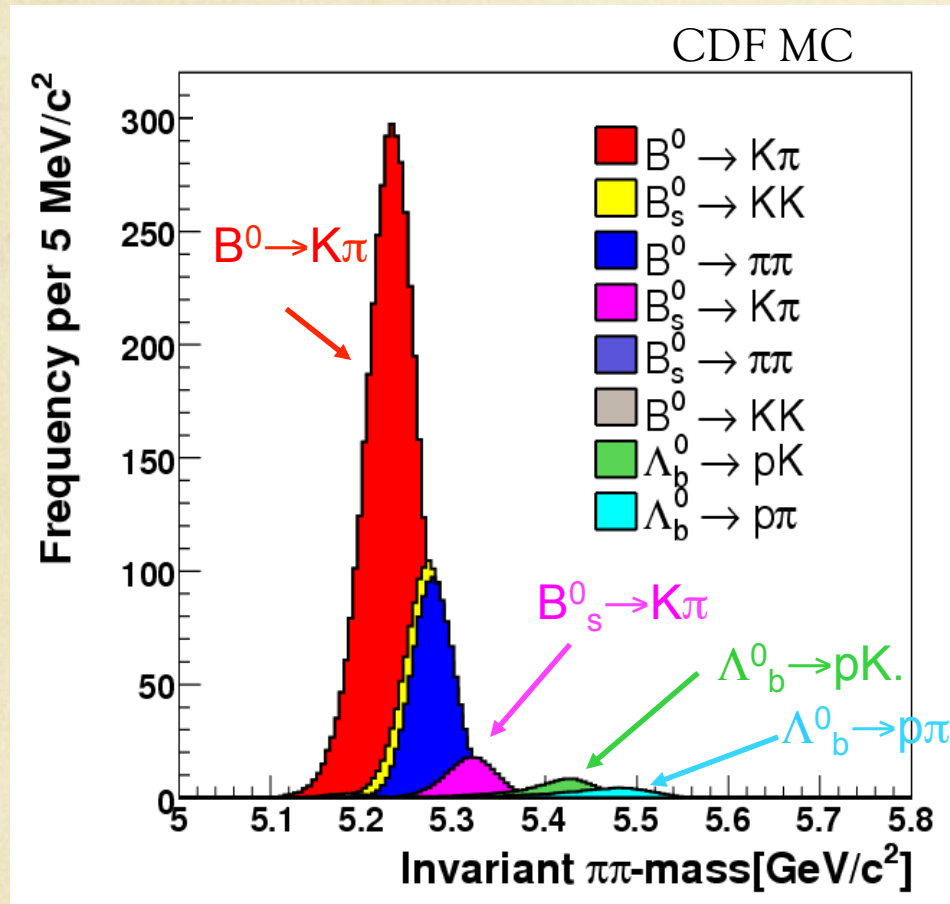
- Among the most widely studied processes.
- Many B^0 , B_s^0 (and Λ_b^0) channels involving similar final states provide crucial experimental information to improve knowledge of strong interactions dynamics.
- Sensitive to V_{ub} phase, CKM angle γ
- Significant contribution from higher-order (“penguin”) transitions provides sensitivity to NP.
- Interference from two diagrams \rightarrow DCPV can be present. Several self-tagging modes:
 — $B^0 \rightarrow K^+ \pi^-$, $B_s^0 \rightarrow K^- \pi^+$, $\Lambda_b^0 \rightarrow p \pi^- / p K^-$



CP Violation in $B \rightarrow K\pi$

- $B^0 \rightarrow K^+\pi^-$
 - established $>5\sigma$, latest measurements are $\approx -10\%$.
 - Genuine SM prediction: $A_{CP}(B^0 \rightarrow K^+\pi^-) \approx A_{CP}(B^+ \rightarrow K^+\pi^0)$. But experimental data do not confirm $A_{CP}(B^+ \rightarrow K^+\pi^0) = 0.040 \pm 0.021$.
 - Still not a firm conclusion: hint of NP? Or effect within SM?
- $B_s^0 \rightarrow K^-\pi^+$
 - Interesting probe of SM origin of direct CP violation in B^0 .
 - $A_{CP}(B_s^0 \rightarrow K\pi) \approx -A_{CP}(B^0 \rightarrow K\pi) \times BR(B^0 \rightarrow K\pi) / BR(B_s^0 \rightarrow K\pi)$ See Gronau [PR B482, 71(2000)] and Lipkin [PLB621,126, (2005)].
- $\Lambda_b^0 \rightarrow p\pi/pK$
 - Must be explored with much better precision. Available CDF measurement at 15% uncertainty.

$B^0_{(s)} \rightarrow h^+ h'^-$ at CDF



Despite good mass resolution ($\approx 24 \text{ MeV}/c^2$), individual modes overlap in a single peak (width $\sim 35 \text{ MeV}/c^2$)

Note that the use of a single mass assignment ($\pi\pi$) causes overlap even with perfect resolution.

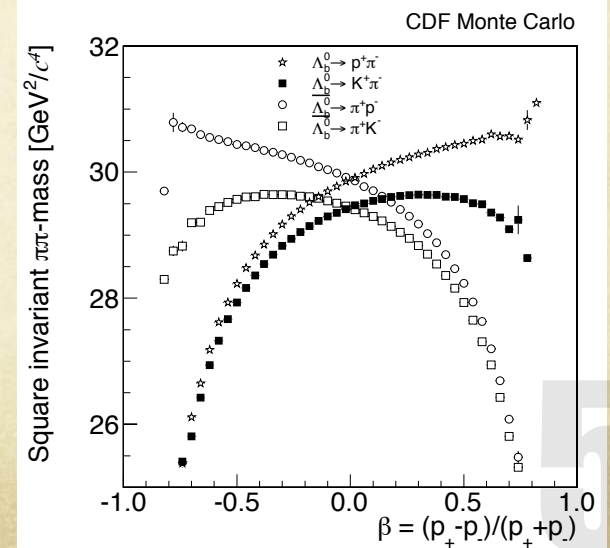
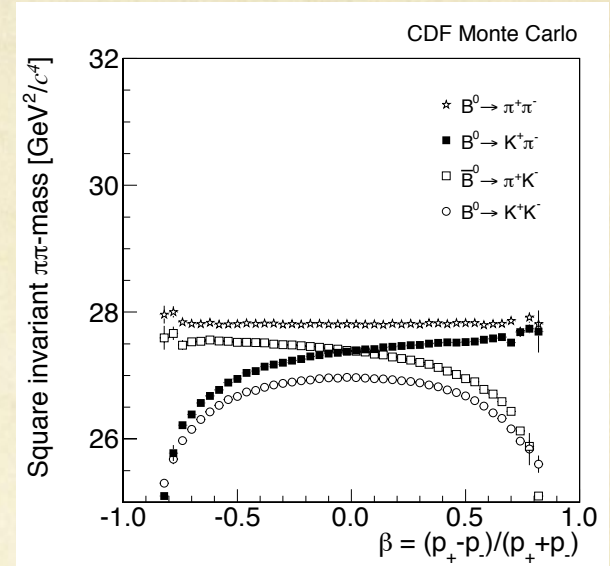
dE/dx from drift chamber does not allow event-by-event separation.

Each mode is a background for others. Much more difficult than B-Factories and LHCb.

Need to determine signal composition with a **Likelihood fit**, combining information from **kinematics** (mass and momenta) and **particle ID** (dE/dx).

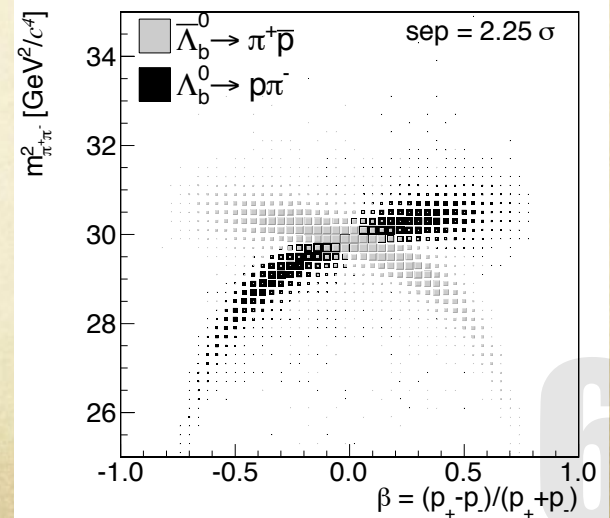
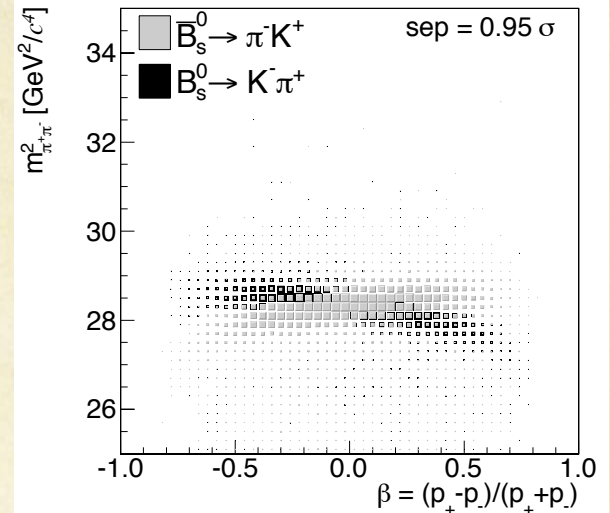
Kinematics

- Exploit dependence between invariant mass and momenta:
 - $m_{\pi\pi}$ invariant $\pi\pi$ -mass.
 - $\beta = (p_+ - p_-)/(p_+ + p_-)$ charged momentum asymmetry.
 - $p_{\text{tot}} = p_+ + p_-$ scalar sum of 3d-momenta.
- This offers good discrimination amongst modes and between $K^+\pi^- / K^-\pi^+$ and $p h^- / \bar{p} h^+$.



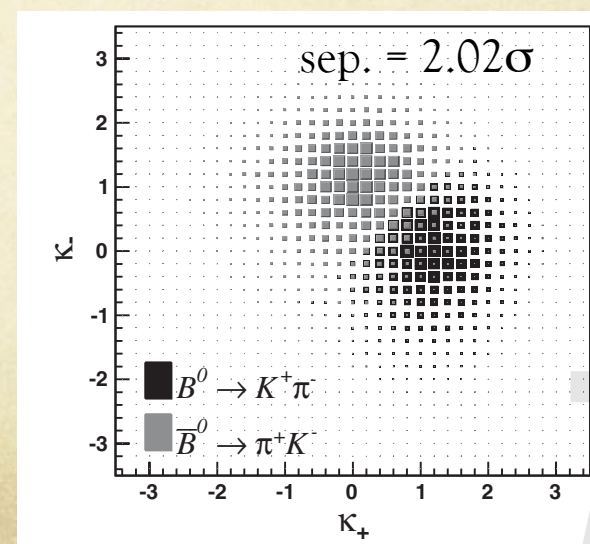
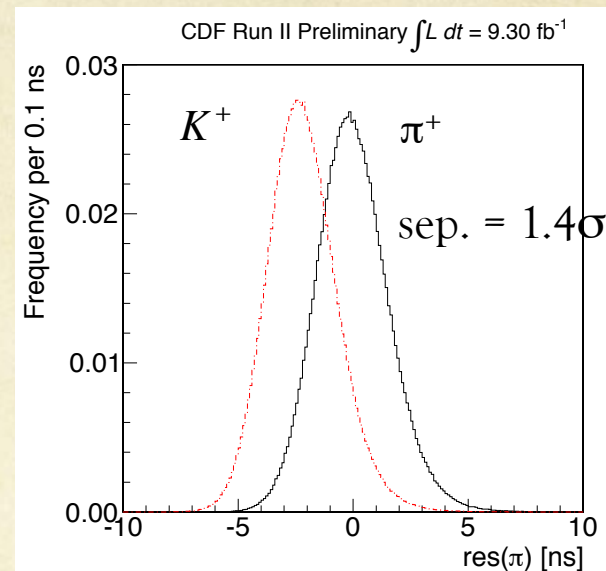
Kinematics

- Exploit dependence between invariant mass and momenta:
 - $m_{\pi\pi}$ invariant $\pi\pi$ -mass.
 - $\beta = (p_+ - p_-)/(p_+ + p_-)$ charged momentum asymmetry.
 - $p_{\text{tot}} = p_+ + p_-$ scalar sum of 3d-momenta.
- This offers good discrimination amongst modes and between $K^+\pi^- / K^-\pi^+$ and $p h^- / \bar{p} h^+$.



Particle Identification (dE/dx)

- Calibration and parameterization with:
 - 4M of strong $D^{*+} \rightarrow D^0 \pi^+ \rightarrow [K \pi^+] \pi^+$
 - 330k of $\Lambda \rightarrow p \pi^-$
- dE/dx accurately calibrated over tracking volume (η, ϕ), hits density, inst. luminosity and time.
- Detailed model includes tails, momentum dependence, charge asymmetries, and two-track correlations.
- 1.4σ K/ π separation at $p > 2 \text{ GeV}/c$.

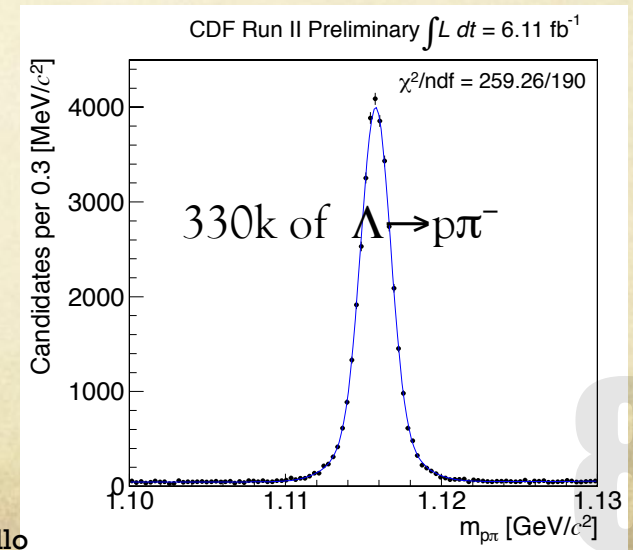
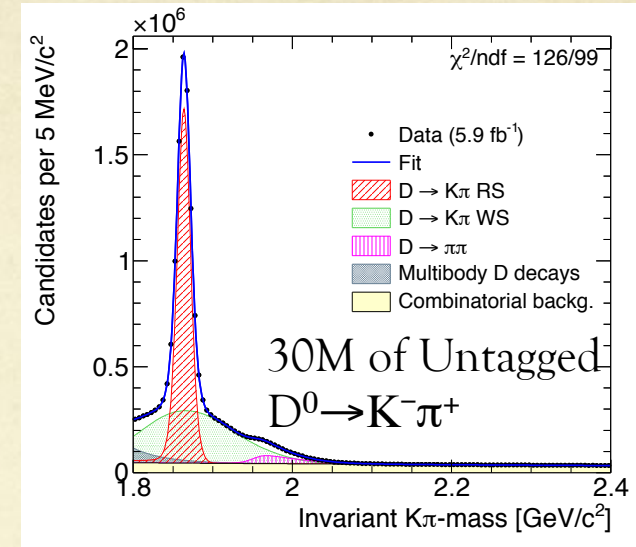


Detector-induced charge asymmetry

$$\frac{\mathcal{B}(b \rightarrow f) - \mathcal{B}(\bar{b} \rightarrow \bar{f})}{\mathcal{B}(b \rightarrow f) + \mathcal{B}(\bar{b} \rightarrow \bar{f})} = \frac{N_{b \rightarrow f} - c_f N_{\bar{b} \rightarrow \bar{f}}}{N_{b \rightarrow f} + c_f N_{\bar{b} \rightarrow \bar{f}}}, \quad (1)$$

where $c_f = \varepsilon(f)/\varepsilon(\bar{f})$ is the ratio between the efficiencies for triggering and reconstructing the final state f with respect to the state \bar{f} . The c_f factors correct for

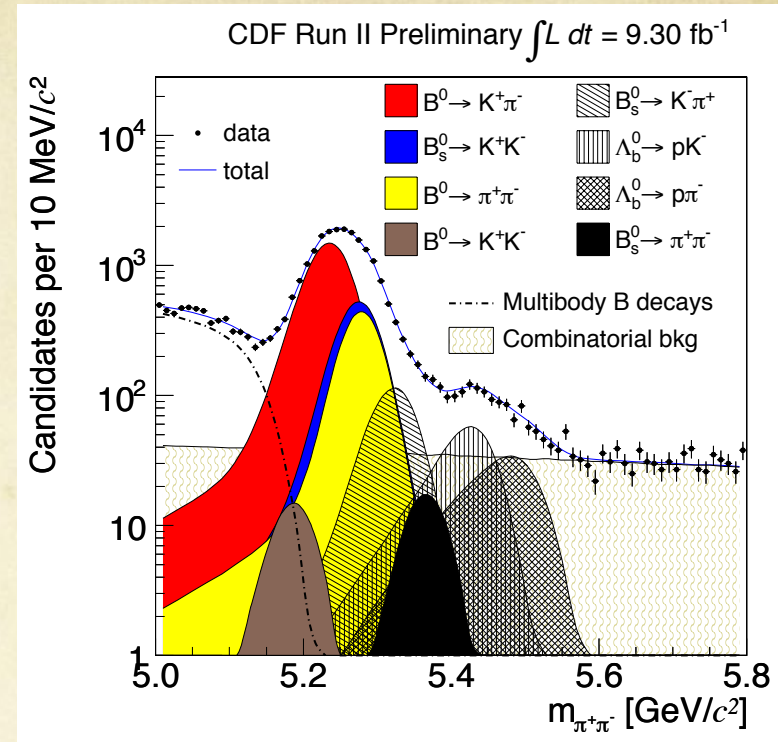
- Extracted from real data.
- Assuming at production $N = \bar{N}$ because:
 - Symmetric initial state $p\bar{p}$
 - Strong interaction is CP-conserving.
 - η symmetric detector.
- CP violation in the decay is negligible.
- Observed raw asymmetries gives c_f .



DCPV results 9.3 fb^{-1}

Final CDF results on this [[CDF-note 10726](#)]

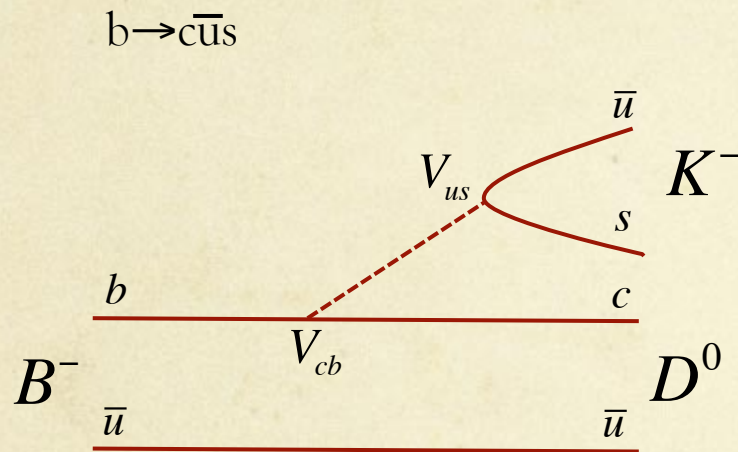
Mode	$\mathcal{N}_{b \rightarrow f}$	$\mathcal{N}_{\bar{b} \rightarrow \bar{f}}$	$A_{CP}(b \rightarrow f)(\%)$
$B^0 \rightarrow K^+ \pi^-$	6348 ± 117	5313 ± 109	$-8.3 \pm 1.3 \pm 0.3$
$B_s^0 \rightarrow K^- \pi^+$	354 ± 46	560 ± 51	$+22 \pm 7 \pm 2$
$\Lambda_b^0 \rightarrow p \pi^-$	242 ± 24	206 ± 23	$+7 \pm 7 \pm 3$
$\Lambda_b^0 \rightarrow p K^-$	271 ± 30	324 ± 31	$-9 \pm 8 \pm 4$



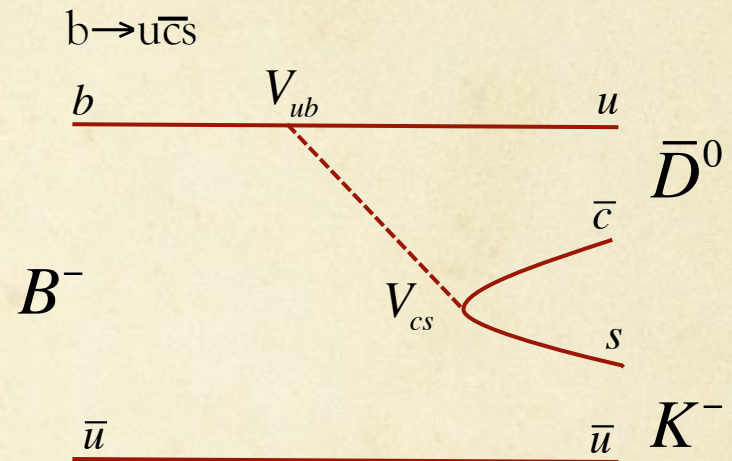
- $A_{CP}(B^0)$ with significance $> 5\sigma$. The same total uncertainty of the world's best measurement from LHCb $[-8.8 \pm 1.1 \pm 0.8]\%$ [[PRL 108 \(2012\) 201601](#)].
- Evidence at 3σ for $A_{CP}(B_s^0)$, confirming LHCb result $[+27 \pm 8 \pm 2]\%$. Same total uncertainty. Gronau-Lipkin test within 1σ confirming a SM origin.
 - W.A. $A_{CP}(B_s^0) = [+24 \pm 5]\%$ to be compared with Gronau-Lipkin prediction $[+31 \pm 4]\%$.
- Uncertainties on $A_{CP}(\Lambda_b^0)$ reached interesting precision (8%). Central value compatible with no CPV. High values are excluded.

Angle γ from $B^- \rightarrow DK^-$

Cleanest ways to measure γ angle. Only tree-level amplitudes are involved. Tiny theoretical uncertainties. Exploit interference between the processes:



Favored $b \rightarrow c$ decay:
 $\sim V_{cb} V_{us}^* \sim \lambda^3$



Color Suppressed $b \rightarrow u$ decay:
 $\sim V_{ub} V_{cs}^* \sim \lambda^3 r_B e^{-i\delta_B} e^{i\gamma}$

Several methods depending on $D^0 \rightarrow f$ and $\bar{D}^0 \rightarrow f$: **GLW** $D \rightarrow \pi\pi/KK$, **ADS** $D \rightarrow K\pi$ **suppressed decays**, etc. No tagging or time dependent analysis is needed, well suited for hadronic environment.

ADS method

- Expected large CP asymmetries.
- Results have to be combined with other methods to obtain γ measurement.

○ Observables:

$$R_{ADS}(h) = \frac{BR(B^- \rightarrow D_{sup} h^-) + BR(B^+ \rightarrow D_{sup} h^+)}{BR(B^- \rightarrow D_{fav} h^-) + BR(B^+ \rightarrow D_{fav} h^+)} \quad \begin{array}{l} h = K \text{ or } \pi \\ D_{fav} \rightarrow K^- \pi^+ \\ D_{sup} \rightarrow K^+ \pi^- \end{array}$$

$$A_{ADS}(h) = \frac{BR(B^- \rightarrow D_{sup} h^-) - BR(B^+ \rightarrow D_{sup} h^+)}{BR(B^- \rightarrow D_{sup} h^-) + BR(B^+ \rightarrow D_{sup} h^+)}$$

From theory:

$$R_{ADS}(K) = r_D^2 + r_B^2 + 2r_B r_D \cos(\delta_B + \delta_D) \cos\gamma$$

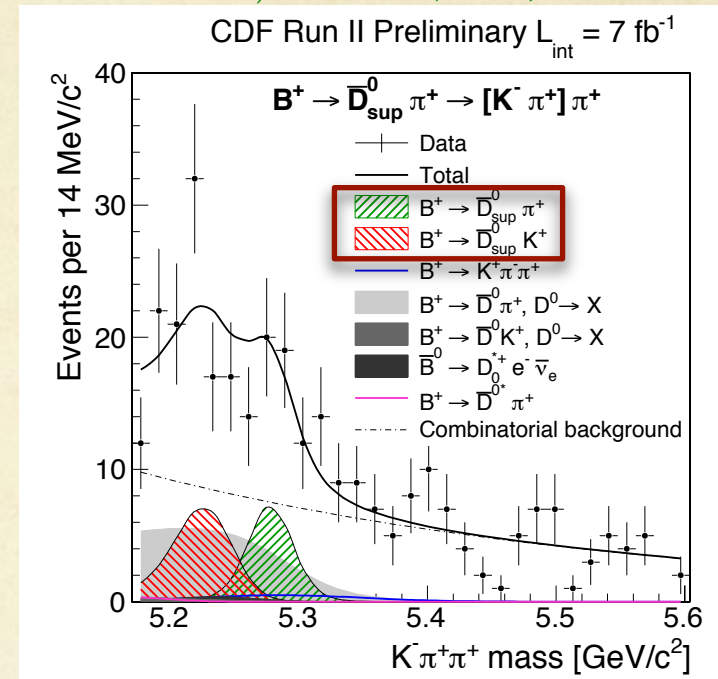
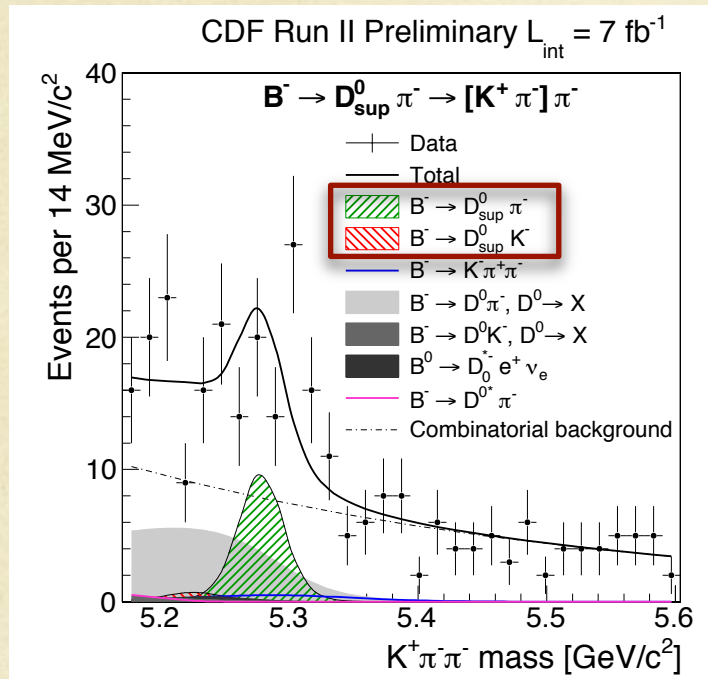
$$A_{ADS}(K) = 2r_B r_D \sin(\delta_B + \delta_D) \sin\gamma / R_{ADS}(K)$$

$$r_B = \left| \frac{A(b \rightarrow u)}{A(b \rightarrow c)} \right| \quad r_D = \left| \frac{A(D^0 \rightarrow K^- \pi^+)}{A(D^0 \rightarrow K^+ \pi^-)} \right|$$

δ_B and δ_D relative strong phases of B and D decays.

Evidence of $B^- \rightarrow D_{\text{sup}}^- K^-$

PRD 84, 091504 (2011)



$$N(B^- \rightarrow D_{\text{sup}}^- K^-) + N(B^+ \rightarrow D_{\text{sup}}^- K^+) = 32 \pm 12$$

$$N(B^- \rightarrow D_{\text{sup}}^- \pi^-) + N(B^+ \rightarrow D_{\text{sup}}^- \pi^+) = 55 \pm 14$$

First Evidence of $B^- \rightarrow D_{\text{sup}}^- K^-$ signal at hadron collider (3.2σ level), later confirmed by LHCb with $>5\sigma$ significance.

Physics observables ($B^- \rightarrow D_{\text{sup}} h^-$)

PRD 84, 091504 (2011)

$$R_{\text{ADS}}(\pi) = [2.8 \pm 0.7(\text{stat}) \pm 0.4(\text{syst})] \cdot 10^{-3}$$

$$A_{\text{ADS}}(\pi) = 0.13 \pm 0.25(\text{stat}) \pm 0.02(\text{syst})$$

$$R_{\text{ADS}}(K) = [22.0 \pm 8.6(\text{stat}) \pm 2.6(\text{syst})] \cdot 10^{-3}$$

$$A_{\text{ADS}}(K) = -0.82 \pm 0.44(\text{stat}) \pm 0.09(\text{syst})$$

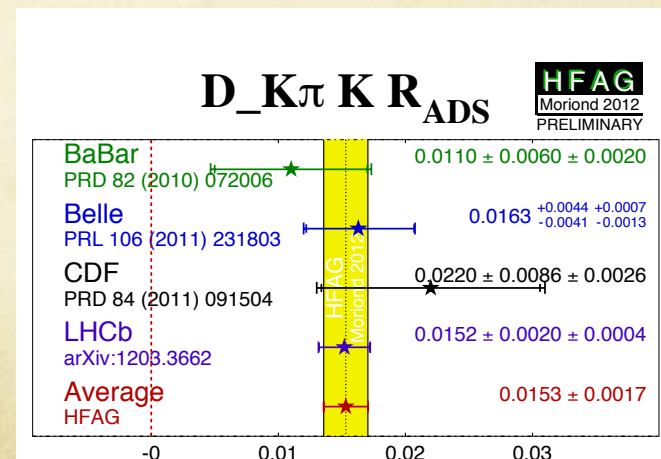
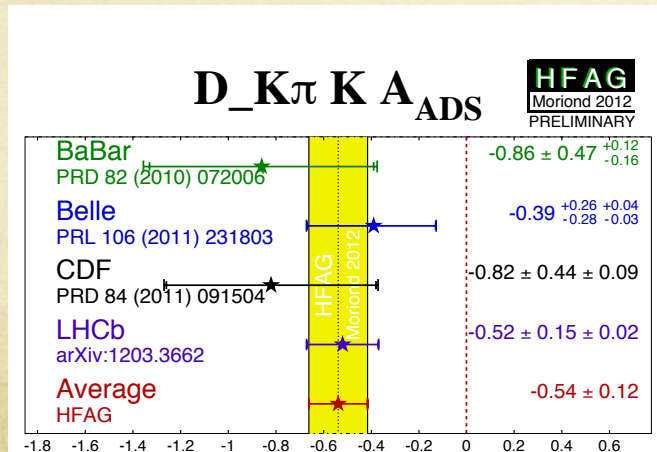
$$B^- \rightarrow D_{\text{fav}} \pi^- \sim 19700 \text{ ev}$$

$$B^- \rightarrow D_{\text{fav}} K^- \sim 1460 \text{ ev}$$

$$B^- \rightarrow D_{\text{sup}} \pi^- \sim 55 \text{ ev}$$

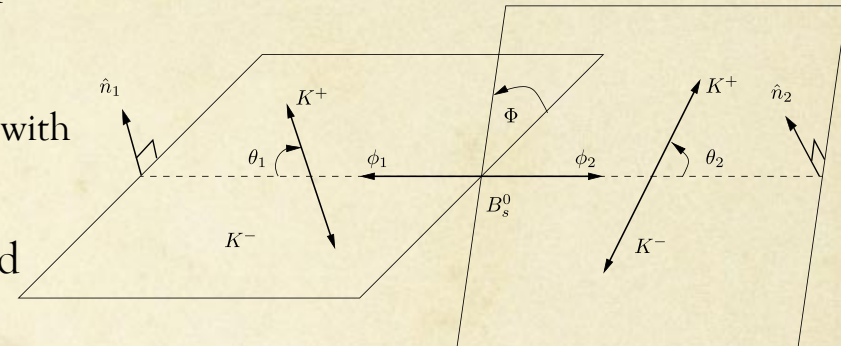
$$B^- \rightarrow D_{\text{sup}} K^- \sim 32 \text{ ev}$$

First measurement of A_{ADS} and R_{ADS} at hadron collider. They agree with other experiments.



$B_s^0 \rightarrow \phi\phi$ at the TeVatron

- BR and polarization amplitudes accessible at CDF [PRL107,261802(2011)]:
 - Found large transverse polarization $(|A_{||}|^2 + |A_{\perp}|^2)/|A_0|^2 = 1.9 \pm 0.2$ in disagreement with SM, naively $\ll 1$
- CP violation expected very tiny, however NP could enhance it.
- The best hard way: full tagged and time-dependent analysis, but statistics still too small.
- However Triple Products (TP) Asymmetries are expected zero in SM. NP could affect those.
- Experimentally accessed by asymmetry of distribution of two angular function u and v . Theory details in *Int. J. of Mod. Phys. A*, 19:2505 (2004) and arXiv:1103.2442.



$$\mathcal{A}_{\text{TP}} = \frac{\Gamma(\vec{p} \cdot (\vec{\varepsilon}_1 \times \vec{\varepsilon}_2) > 0) - \Gamma(\vec{p} \cdot (\vec{\varepsilon}_1 \times \vec{\varepsilon}_2) < 0)}{\Gamma(\vec{p} \cdot (\vec{\varepsilon}_1 \times \vec{\varepsilon}_2) > 0) + \Gamma(\vec{p} \cdot (\vec{\varepsilon}_1 \times \vec{\varepsilon}_2) < 0)},$$

ε_i can be either spins or momenta. TP is odd under time reversal and sensitive to CPV.

$$u = \cos \Phi \sin \Phi \longrightarrow A_{||} A_{\perp}$$

$$v = \begin{cases} \sin \Phi & \text{if } \cos \vartheta_1 \cos \vartheta_2 > 0 \\ \sin(-\Phi) & \text{if } \cos \vartheta_1 \cos \vartheta_2 < 0 \end{cases} \longrightarrow A_0 A_{\perp}$$

CPV in $B_s^0 \rightarrow \phi\phi$ (2.9 fb^{-1})

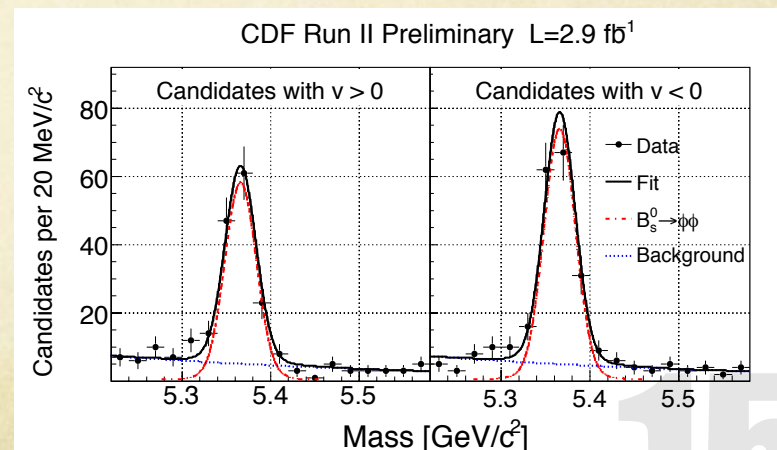
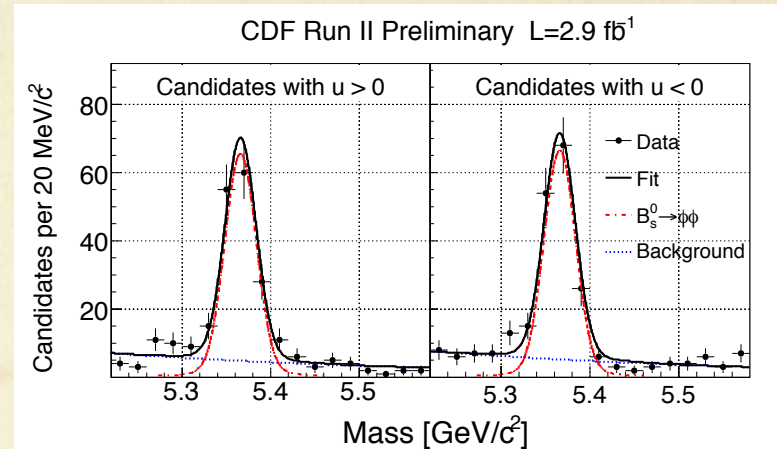
PRL107,261802(2011)

- No tagging and time-dependent analysis is required.
- Sensitive to CP V both in mixing and decay.
- Unbinned ML fit on $\approx 300 B_s^0 \rightarrow \phi\phi$

$$A_u = (-0.8 \pm 6.4 \pm 1.8)\%$$

$$A_v = (-12.0 \pm 6.4 \pm 1.6)\%$$

- In agreement with recent and more precise (by a factor 2) LHCb results [PLB 713,369 (2012)].
- Need to update with final sample ($\approx 10 \text{ fb}^{-1}$).



Conclusions

- Data taking ended in September 30th 2011. Getting analyses finalized in full dataset.
- CDF keeps contributing to HF while passing baton to LHC experiments.
- Will focus on measurements that are unique to TeVatron or systematics-limited.
- Still interesting results to come.

Backup

Introduction

- Non invariance of the fundamental interactions under CP in an established experimental fact.
- Vast majority of experimental data have supported the success of the CKM theory.
- However additional sources of CP violation are required to explain matter-antimatter asymmetry in the Universe (the famous Sakharov argument).
- The hunting is still open.
 - Charm and beauty sector still not fully explored.

Direct CP-violation

$$\begin{array}{lcl}
\left| \overline{B} \rightarrow f \right|^2 & \neq & \left| B \rightarrow \bar{f} \right|^2 \\
A = \langle f | H | \bar{B} \rangle & & \bar{A} = \langle \bar{f} | H | B \rangle \\
\frac{\bar{A}}{A} \neq 1 \Leftrightarrow \text{Direct CPV} & & A(\bar{B} \rightarrow f) = e^{+i\varphi_1}|A_1|e^{i\delta_1} + e^{+i\varphi_2}|A_2|e^{i\delta_2} \\
& & A(B \rightarrow \bar{f}) = e^{-i\varphi_1}|A_1|e^{i\delta_1} + e^{-i\varphi_2}|A_2|e^{i\delta_2}
\end{array}$$

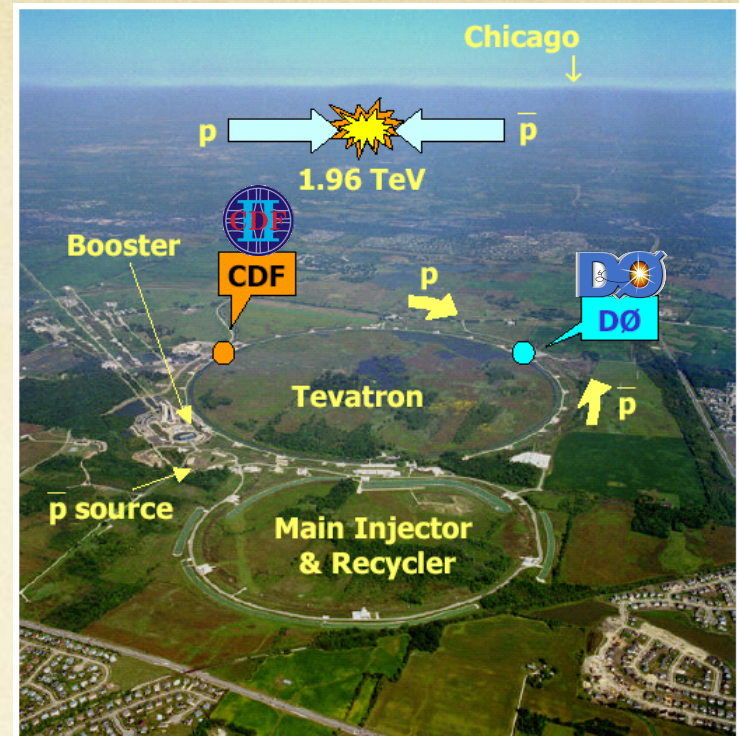
$$\begin{aligned} \mathcal{A}_{\text{CP}} &\equiv \frac{\Gamma(\bar{B} \rightarrow \bar{f}) - \Gamma(B \rightarrow f)}{\Gamma(\bar{B} \rightarrow \bar{f}) + \Gamma(B \rightarrow f)} = \frac{|A(\bar{B} \rightarrow \bar{f})|^2 - |A(B \rightarrow f)|^2}{|A(\bar{B} \rightarrow \bar{f})|^2 + |A(B \rightarrow f)|^2} \\ &= -\frac{2|A_1||A_2|\sin(\delta_1 - \delta_2)\sin(\varphi_1 - \varphi_2)}{|A_1|^2 + 2|A_1||A_2|\cos(\delta_1 - \delta_2)\cos(\varphi_1 - \varphi_2) + |A_2|^2}. \end{aligned}$$

$\varphi_1 - \varphi_2 = \text{angle } \gamma \text{ in the } B^0 \rightarrow K^+ \pi^-$

A non-vanishing value can be generated through the interference between the two weak amplitudes, provided both a non-trivial weak phase difference $\varphi_1 - \varphi_2$ and a non-trivial strong phase difference $\delta_1 - \delta_2$ are present.

Fermilab Tevatron

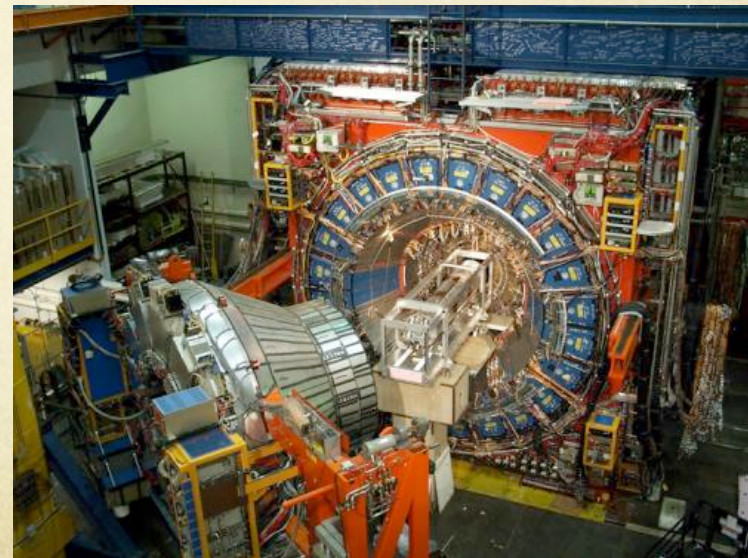
- $p\bar{p}$ collisions at 1.96 TeV
- Peak luminosity $3.5\text{--}4 \times 10^{32}\text{cm}^{-2}\text{s}^{-1}$
- $\sim 10\text{ fb}^{-1}$ “good” data on tape per experiment.
- End of operation in September 2011.



CDFII detector

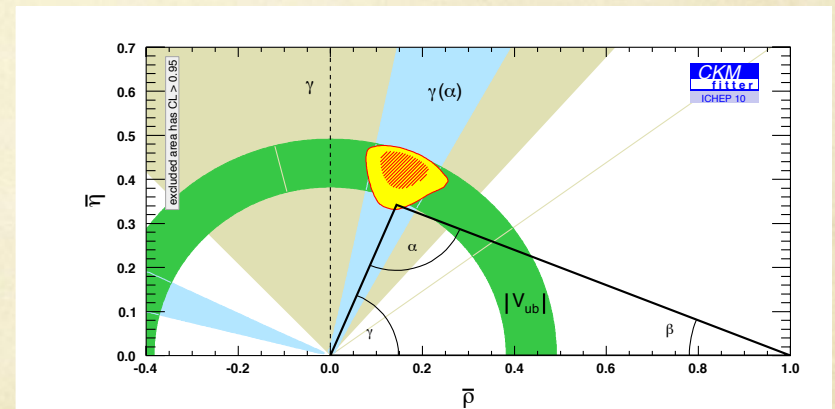
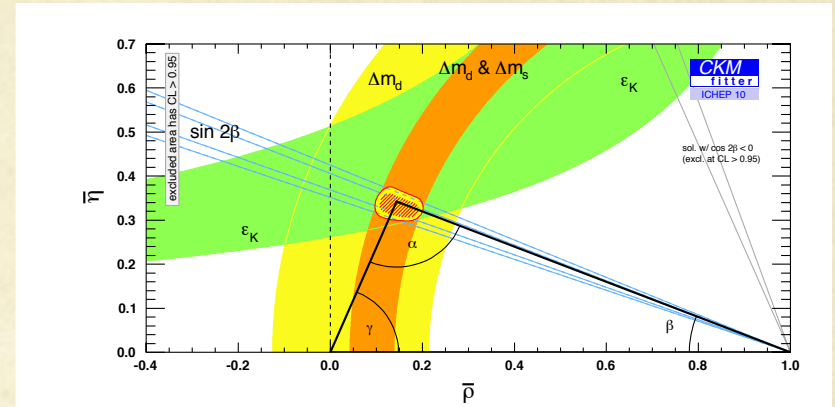


- Central Drift Chamber ($\delta p_T/p_T \sim 0.0015 (\text{GeV}/c)^{-1} p_T$)
- Silicon Vertex Detector (Hadronic Trigger)
- Particle identification (dE/dx and TOF)



Trees and loops for γ measurement

- Loops:
 - Better constraints.
 - New Physics may enter.
- Trees:
 - Less well constrained.
 - $\sim 20^\circ$ uncertainty on γ .
 - Insensitive to New Physics.



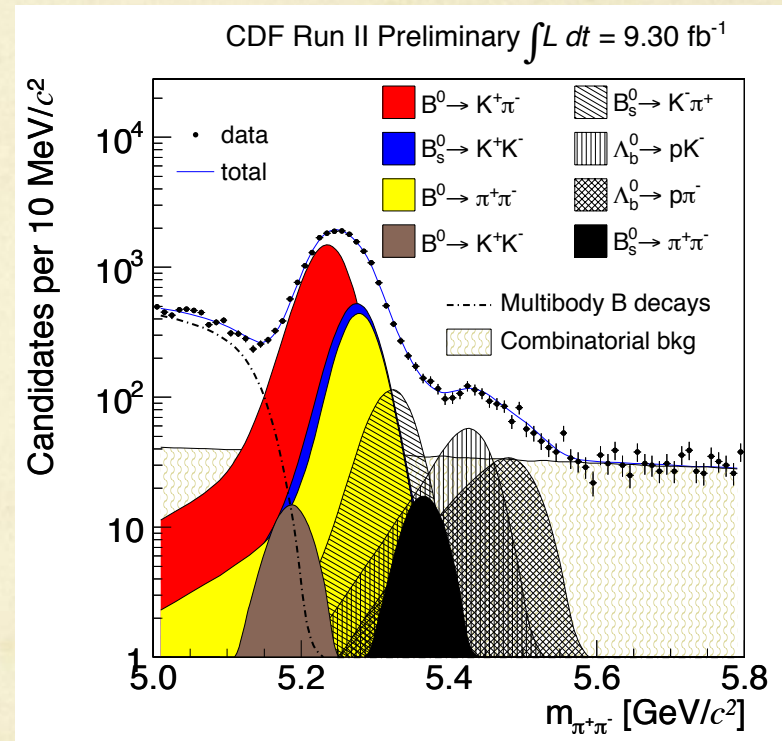
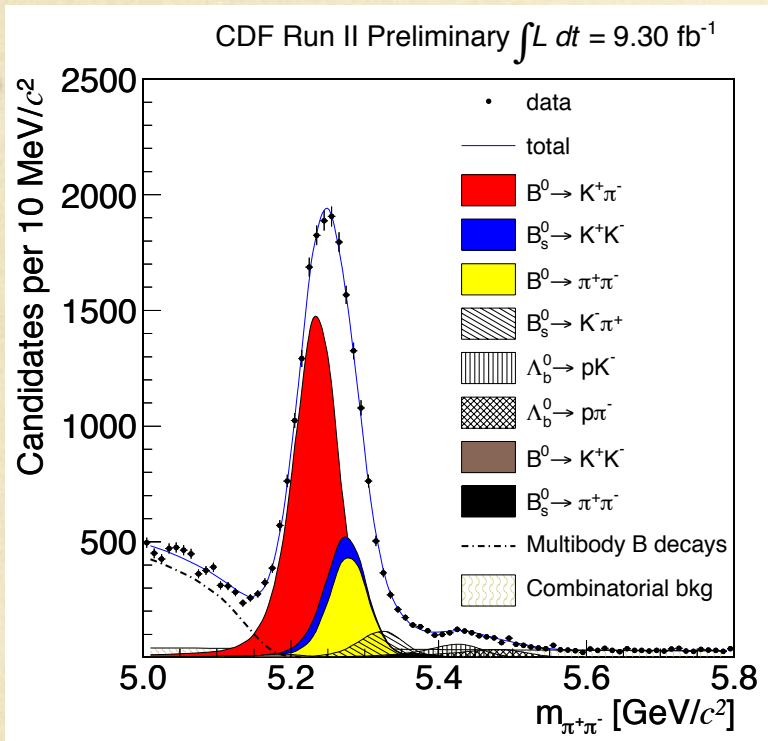
Very interesting to compare at high precision the two approaches.

Systematic uncertainties

TABLE II: Summary of the systematic uncertainties.

source	$A_{CP}(B^0 \rightarrow K^+ \pi^-)$	$A_{CP}(B_s^0 \rightarrow K^- \pi^+)$	$A_{CP}(\Lambda_b^0 \rightarrow p \pi^-)$	$A_{CP}(\Lambda_b^0 \rightarrow p K^-)$
Charge asymm. of momentum p.d.f	0.0011	0.0025	0.0009	0.0022
Signals momentum p.d.f.	0.0013	0.0043	0.0054	0.0103
Combinatorial back. momentum p.d.f	0.0004	0.0072	0.0257	0.0065
Physics back. momentum p.d.f	0.0008	0.0002	0.0003	0.0004
Signals mass p.d.f.	0.0002	0.0066	0.0018	0.0006
Combinatorial back. mass p.d.f.	<0.0001	0.0001	<0.0001	<0.0001
Physics back. mass p.d.f	0.0001	0.0006	0.0005	0.0001
Particle Identification model	0.0023	0.0066	0.0040	0.0046
Charge asymmetry	0.0014	0.0013	0.0094	0.0096
Triggers relative efficiency	0.0003	0.0083	0.0004	0.0034
Nominal b -hadrons masses	0.0001	0.0049	0.0007	0.0008
$p_T(\Lambda_b^0)$ spectrum	0.0001	0.0010	0.0052	0.0021
Λ_b^0 polarization	<0.0001	0.0027	0.0089	0.0364
TOTAL	0.003	0.02	0.03	0.04

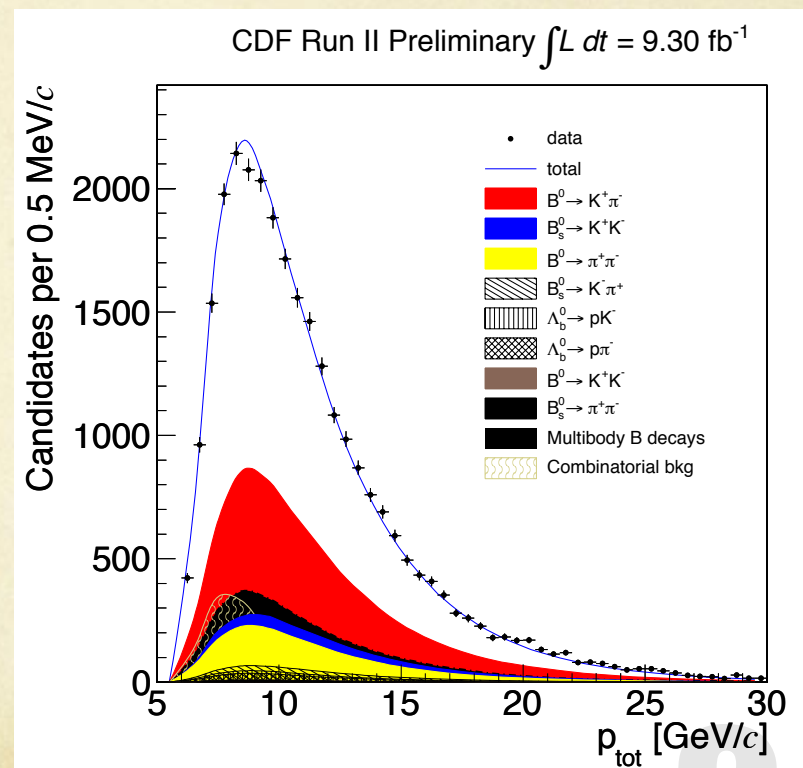
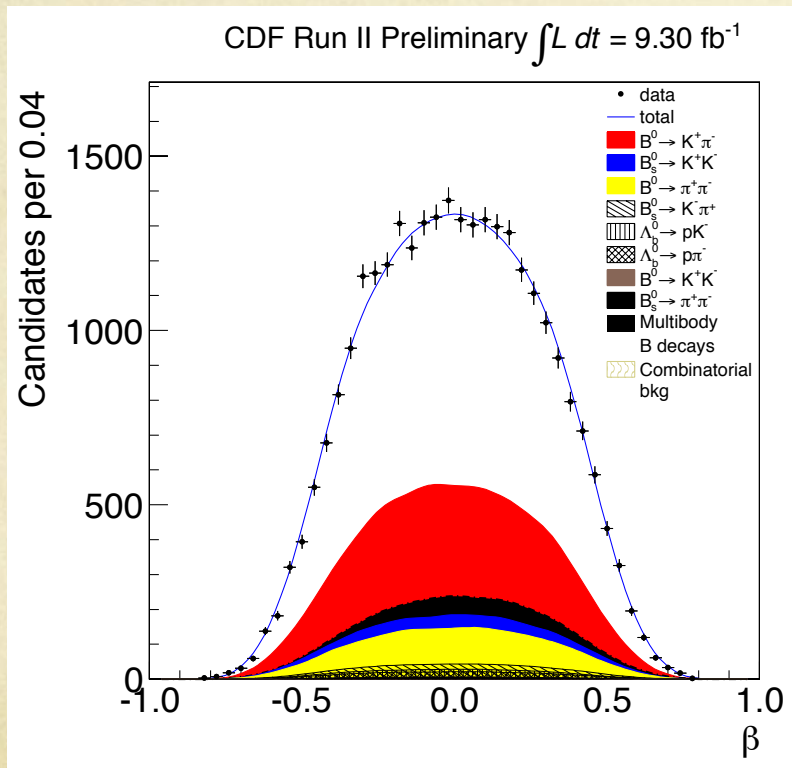
Invariant $\pi\pi$ -mass



Momentum observables

$$\beta = \frac{p_+ - p_-}{p_+ + p_-}$$

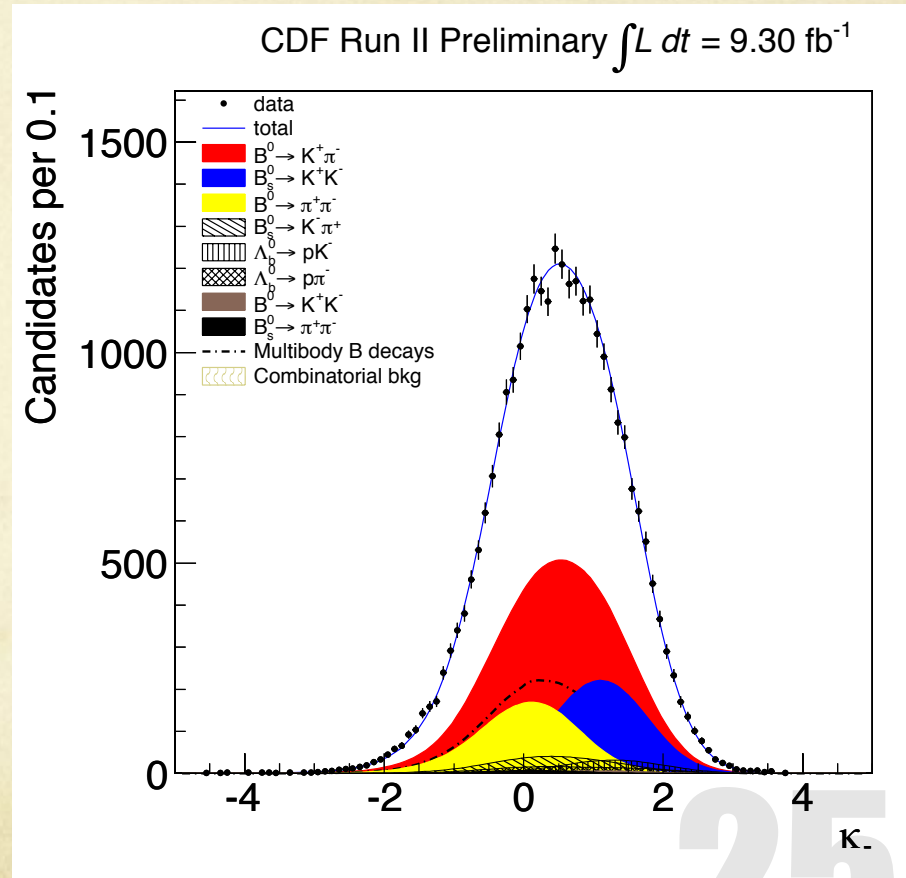
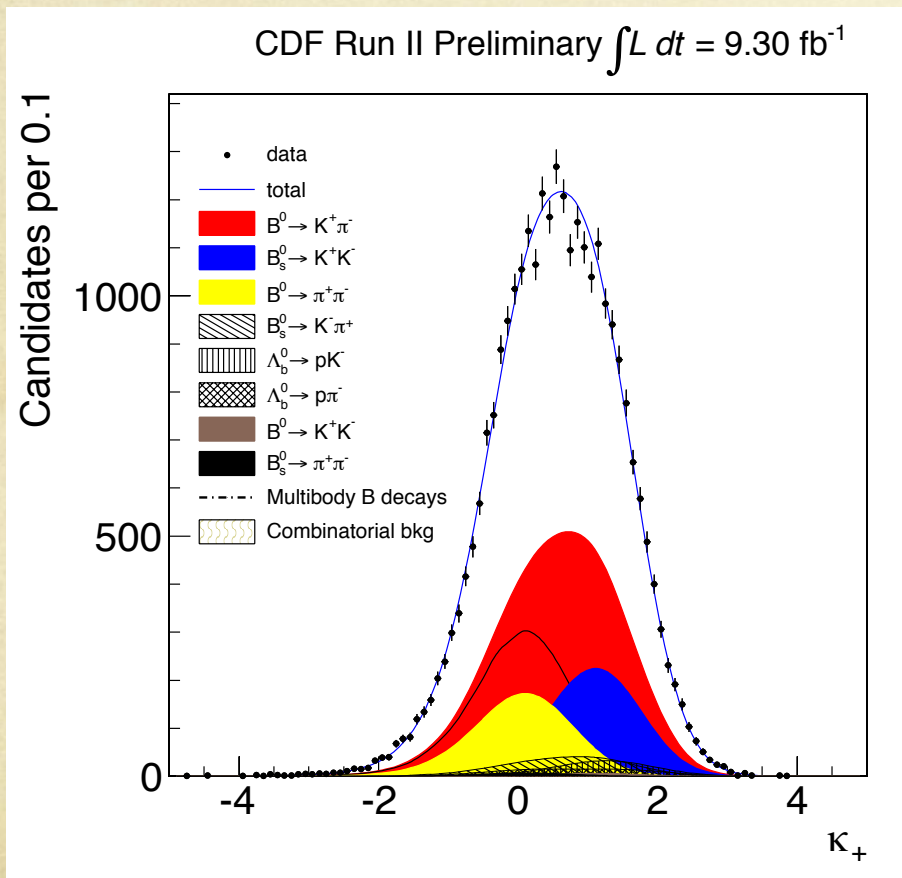
$$p_{tot} = p_+ + p_-$$



dE/dx observables

$\langle k \rangle$ in pion hypothesis is 0

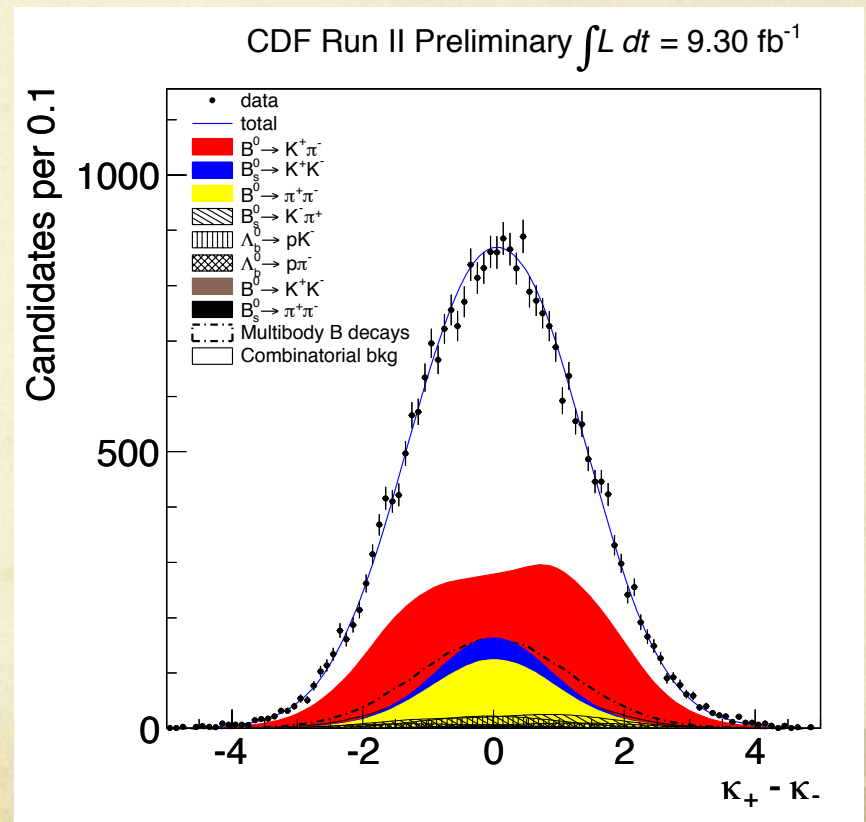
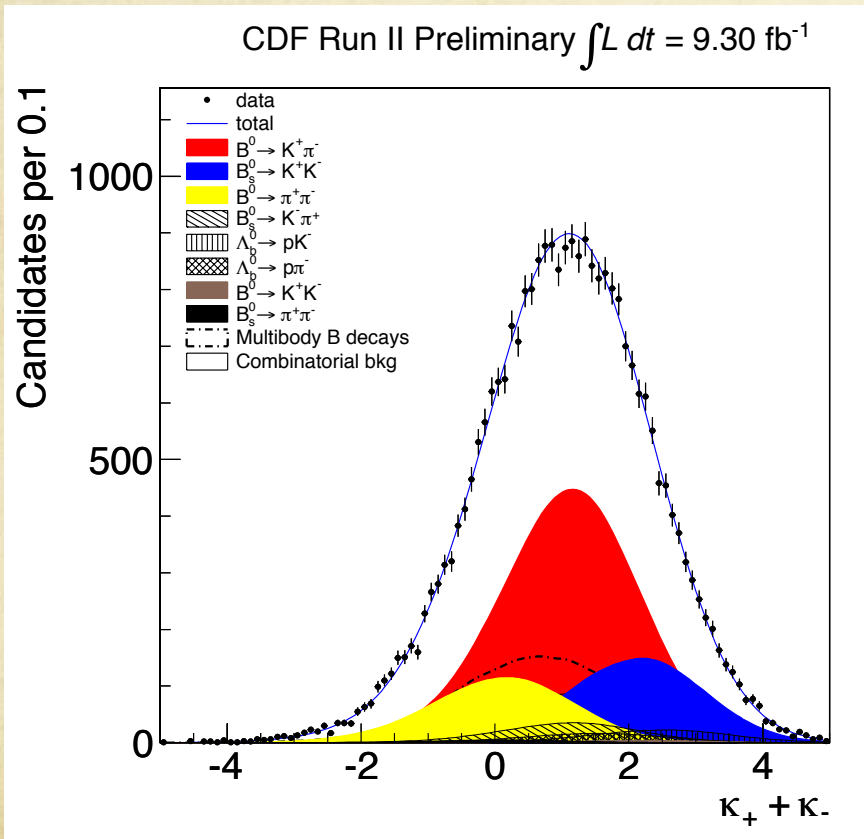
$\langle k \rangle$ in kaon hypothesis is 1



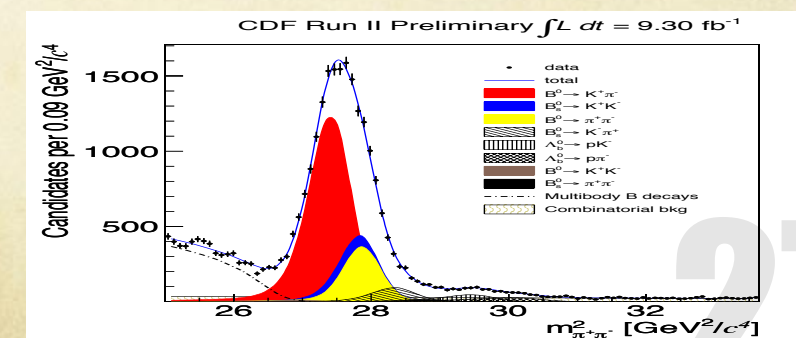
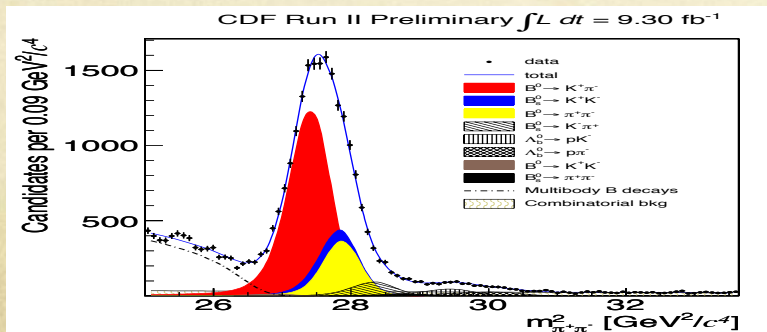
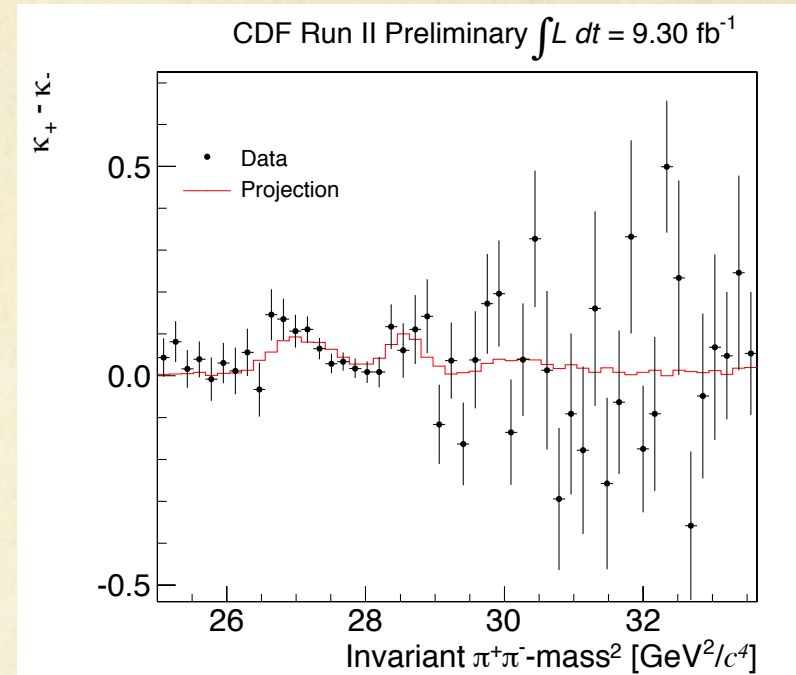
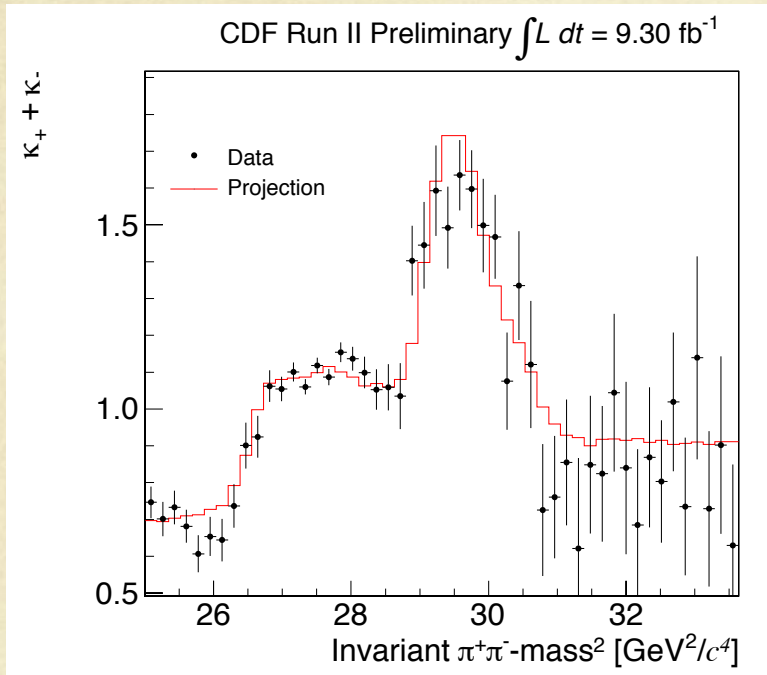
dE/dx observables

$\langle k \rangle$ in pion hypothesis is 0

$\langle k \rangle$ in kaon hypothesis is 1



PID vs $m_{\pi\pi}^2$

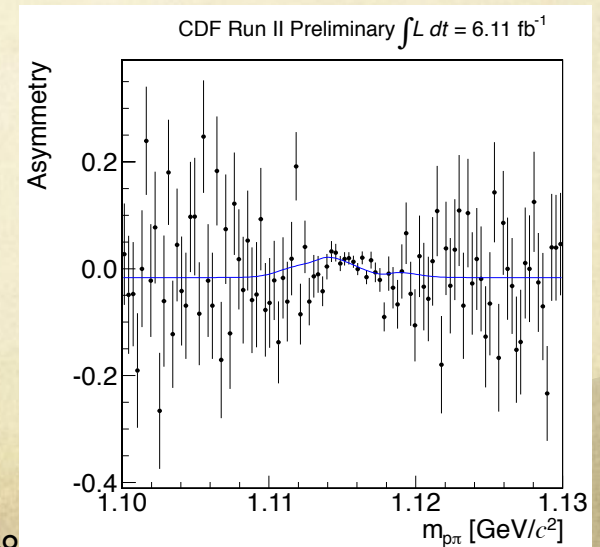
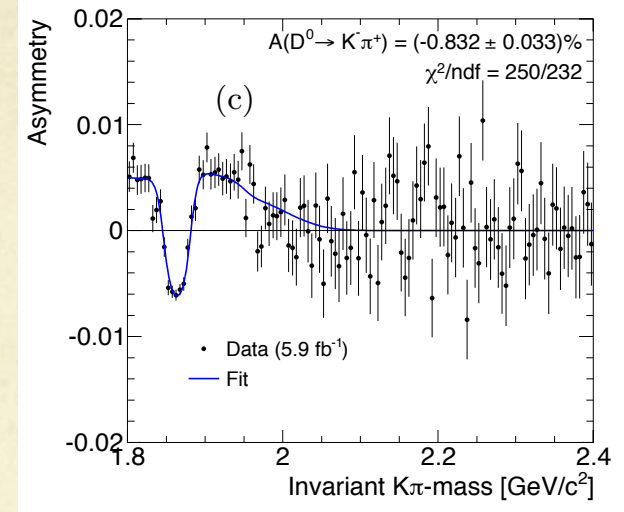


Detector-induced charge asymmetry

$$\frac{\mathcal{B}(b \rightarrow f) - \mathcal{B}(\bar{b} \rightarrow \bar{f})}{\mathcal{B}(b \rightarrow f) + \mathcal{B}(\bar{b} \rightarrow \bar{f})} = \frac{N_{b \rightarrow f} - c_f N_{\bar{b} \rightarrow \bar{f}}}{N_{b \rightarrow f} + c_f N_{\bar{b} \rightarrow \bar{f}}}, \quad (1)$$

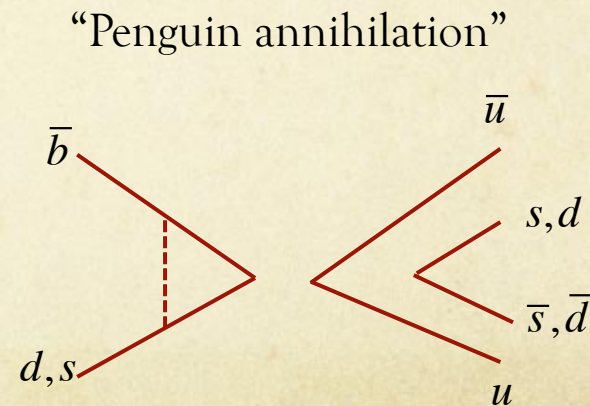
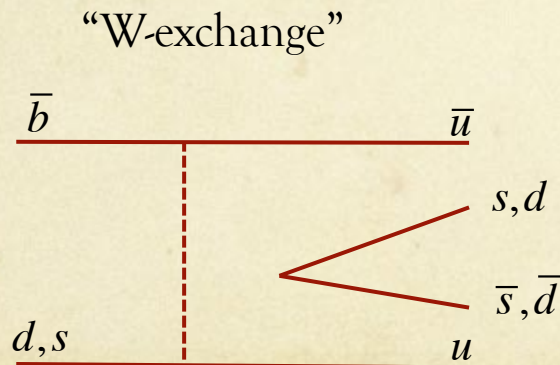
where $c_f = \varepsilon(f)/\varepsilon(\bar{f})$ is the ratio between the efficiencies for triggering and reconstructing the final state f with respect to the state \bar{f} . The c_f factors correct for

- Extracted from real data.
- Assuming at production $N = \bar{N}$ because:
 - Symmetric initial state $p\bar{p}$
 - Strong interaction is CP-conserving.
 - η symmetric detector.
- CP violation in the decay is negligible.
- Observed raw asymmetries gives c_f .



Annihilation topologies

- All initial-state quarks undergo a transition.
- Not yet observed. Small BR $\sim 10^{-7}$, with large uncertainties.
- Uncertainty depends on hard-to-predict hadronic parameters
 - large source of uncertainty in many other calculations.



Evidence of $B_s^0 \rightarrow \pi^+\pi^-$ (6fb^{-1})

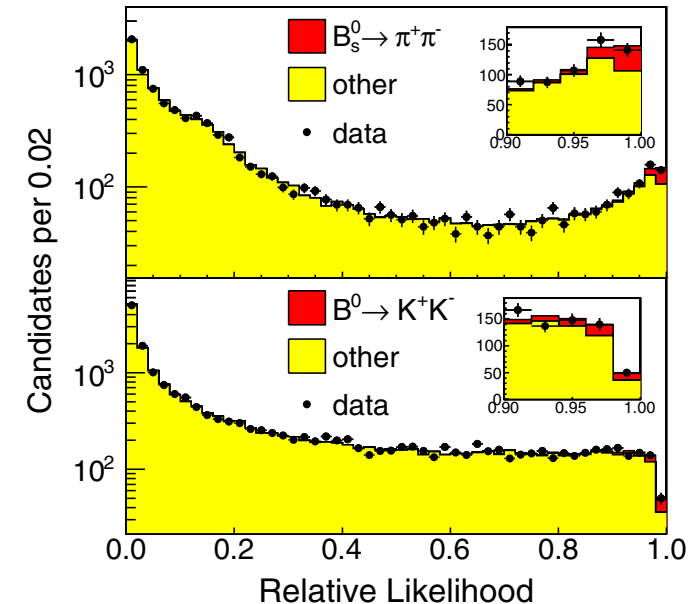
PRL 108, 211803 (2012)

Mode	N_s	Significance
$B^0 \rightarrow K^+K^-$	$120 \pm 49 \pm 42$	2.0σ
$B_s^0 \rightarrow \pi^+\pi^-$	$94 \pm 28 \pm 11$	3.7σ

$$BR(B_s^0 \rightarrow \pi^+\pi^-) = [0.57 \pm 0.15(\text{stat}) \pm 0.10(\text{syst})] \times 10^{-6}$$

$$BR(B^0 \rightarrow K^+K^-) \in [0.05, 0.46] \times 10^{-6} @ 90\%CL$$

$$BR(B^0 \rightarrow K^+K^-) = [0.23 \pm 0.10(\text{stat}) \pm 0.10(\text{syst})] \times 10^{-6}$$



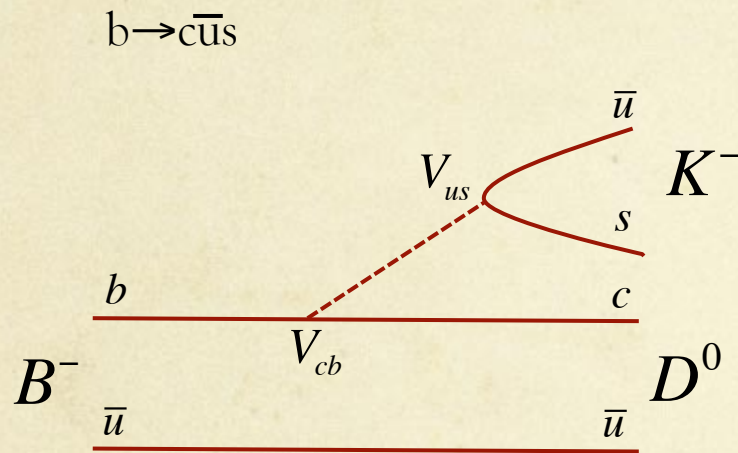
Consistent with previous upper limits from CDF, $B_s^0 \rightarrow \pi^+\pi^-$ confirmed later by LHCb observation.

$B_s^0 \rightarrow \pi^+\pi^-$ in agreement with recent pQCD estimates, higher than other predictions.

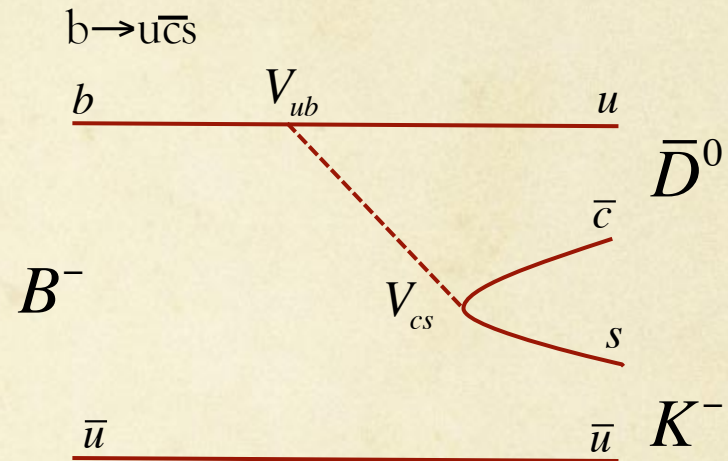
$B^0 \rightarrow K^+K^-$ in agreement with predictions, but large theoretical uncertainty on them.

Angle γ from $B^- \rightarrow DK^-$

Cleanest ways to measure γ angle. Only tree-level amplitudes are involved. Tiny theoretical uncertainties. Exploit interference between the processes:



Favored $b \rightarrow c$ decay:
 $\sim V_{cb} V_{us}^* \sim \lambda^3$



Color Suppressed $b \rightarrow u$ decay:
 $\sim V_{ub} V_{cs}^* \sim \lambda^3 r_B e^{-i\delta_B} e^{i\gamma}$

Several methods depending on $D^0 \rightarrow f$ and $\bar{D}^0 \rightarrow f$: **GLW** $D \rightarrow \pi\pi/KK$, **ADS** $D \rightarrow K\pi$ **suppressed decays**, etc. No tagging or time dependent analysis is needed, well suited for hadronic environment.

CDF provided results for **GLW** method in 1fb^{-1} [**PRD81**, **031105(2010)**].


ADS method

ADS method [[PRL78,3257\(1997\)](#);[PRD63,036005\(2001\)](#)] uses the $B^- \rightarrow D K^-$ decays with D reconstructed in $D \rightarrow K^+ \pi^-$:

$B^- \rightarrow D^0 K^- \rightarrow [K^+ \pi^-] K^-$  Color allowed $B^- \rightarrow D K^-$ and Doubly Cabibbo Suppressed $D^0 \rightarrow K^+ \pi^-$.

$B^- \rightarrow \bar{D}^0 K^- \rightarrow [K^+ \pi^-] K^-$  Color suppressed $B^- \rightarrow D K^-$ and Cabibbo Favored $\bar{D}^0 \rightarrow K^+ \pi^-$.

$$\left| \frac{\mathcal{M}(B^- \rightarrow K^- D^0 [\rightarrow f])}{\mathcal{M}(B^- \rightarrow K^- \bar{D}^0 [\rightarrow f])} \right|^2 \approx \left| \frac{V_{cb} V_{us}^*}{V_{ub} V_{cs}^*} \right|^2 \left| \frac{a_1}{a_2} \right|^2 \frac{Br(D^0 \rightarrow f)}{Br(\bar{D}^0 \rightarrow f)} \approx 1$$

 color suppression

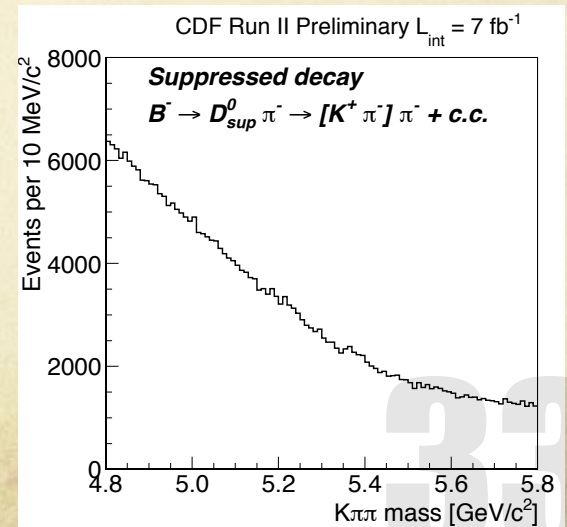
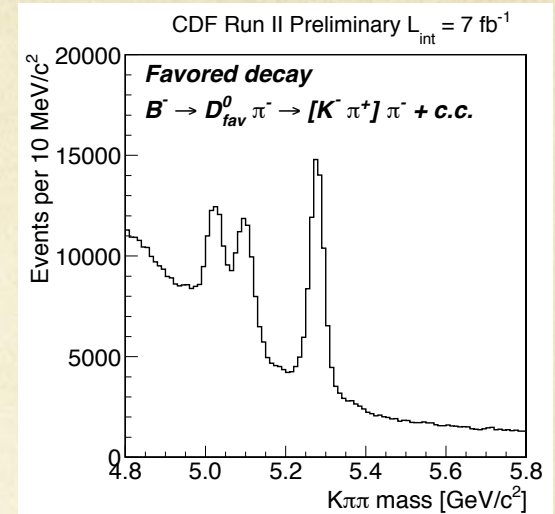
$B^- \rightarrow D K^- \rightarrow [K^+ \pi^-] K^-$ suppressed by factor of about 10^{-3} wrt favored $B^- \rightarrow D K^- \rightarrow [K^- \pi^+] K^-$

The two interfering amplitudes are comparable. Large CP violation can be observed.

$B^- \rightarrow DK^-$ ADS analysis

Before optimization

- Selection is crucial to search for highly suppressed signals.
- Optimal point chosen using large sample of favored decays (same final states).
 - Maximize the sensitivity for discovery of limit setting for an unobserved mode [[physics/0308063](#)].
- Simultaneous Extended Unbinned Maximum Likelihood fit on Favored and Suppressed modes.
- Using **masses** and **particle identification** (dE/dx) information to determine the signal composition.



$B^- \rightarrow DK^-$ ADS analysis

After optimization

- Selection is crucial to search for highly suppressed signals.
- Optimal point chosen using large sample of favored decays (same final states).
 - Maximize the sensitivity for discovery of limit setting for an unobserved mode [[physics/0308063](#)].
- Simultaneous Extended Unbinned Maximum Likelihood fit on Favored and Suppressed modes.
- Using **masses** and **particle identification** (dE/dx) information to determine the signal composition.

